

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。普通物理共 50 題選擇題，每題答對得 2 分，答錯倒扣 0.4 分；滿分 100 分，倒扣至 0 分為止。

1. For a system at constant U and V, which of the following is the criterion of equilibrium?

- Ⓐ $dA=0$, Ⓑ $dS=0$, Ⓒ $dT=0$, Ⓓ $dH=0$, Ⓔ $dG=0$.

2. The infinitesimal variation of Gibbs free energy with temperature at constant pressure defines

- Ⓐ enthalpy, Ⓑ entropy, Ⓒ internal energy, Ⓓ heat capacity, Ⓔ volume.

3. Which of the following is a condition of a regular solution?

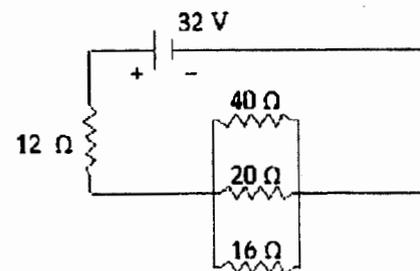
- Ⓐ enthalpy of mixing equals to zero, Ⓑ entropy of mixing equals to zero, Ⓒ Gibbs free energy of mixing equals to zero, Ⓓ entropy of mixing equals to entropy of mixing of an ideal solution, Ⓔ none of the above is applicable.

4. When an ideal gas undergoes an isothermal process, which is the work done by the system?

- Ⓐ $PT \ln(V_1/V_2)$, Ⓑ $PT \ln(V_2/V_1)$, Ⓒ $PT \ln(P_1/P_2)$, Ⓓ $PT \ln(P_2/P_1)$, Ⓔ none of above.

5. When compressing a liter of an ideal gas 0.5 liter by the three different reversible processes (1) isobarically, (2) isothermally, and (3) adiabatically, the work needed would be

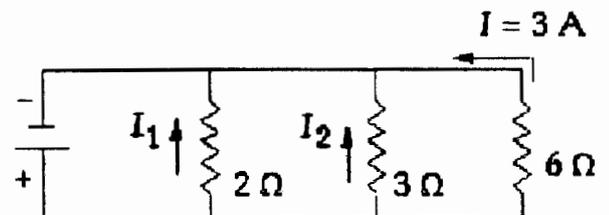
- Ⓐ $W_1 > W_2 > W_3$, Ⓑ $W_2 > W_1 > W_3$, Ⓒ $W_3 > W_1 > W_2$, Ⓓ $W_1 > W_3 > W_2$, Ⓔ $W_2 > W_3 > W_1$.



6. In this circuit, the current I through the battery is approximately

- Ⓐ 1.7 A Ⓑ 4.4 A Ⓒ 0.36 A Ⓓ 0.60 A Ⓔ 3.4 A

7. You connect resistors of 2 Ω, 3 Ω, and 6 Ω in parallel across a battery. The current through the 6-Ω resistor



is 3 A. What are the currents in the other two resistors?

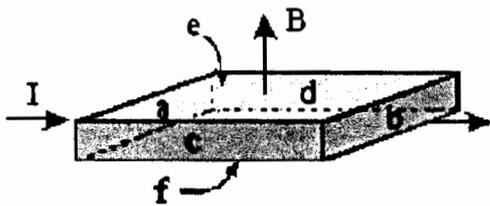
- Ⓐ $I_1 = 9 \text{ A}; I_2 = 6 \text{ A}$ Ⓑ $I_1 = 6 \text{ A}; I_2 = 9 \text{ A}$ Ⓒ $I_1 = 1 \text{ A}; I_2 = 1.5 \text{ A}$ Ⓓ The answer cannot be obtained without knowing the emf of the battery. Ⓔ None of these is correct.

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8. A 20.0- μF capacitor is charged to 200 V and is then connected across a 1000- Ω resistor. What is the initial current just after the capacitor is connected to the resistor?

- (A) 100 mA (B) 200 mA (C) 150 mA (D) 300 mA (E) 50 mA

9. A current I passes through a slab of metal in the presence of a magnetic field B . Between which two sides does a Hall voltage develops? Write the side with the higher potential first.

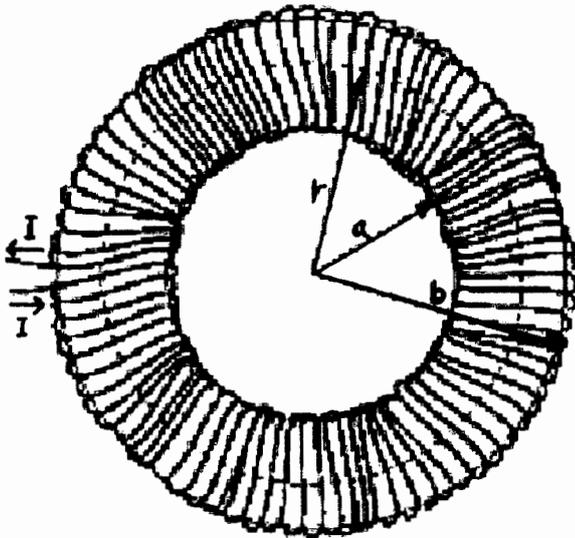


- (A) a and b (B) c and d (C) e and f (D) b and a (E) d and c

10. Two straight rods 60 cm long and 2.0 mm apart in a current balance carry currents of 18 A each in opposite directions. What mass must be placed on the upper rod to balance the magnetic force of repulsion?

- (A) 0.50 g (B) 0.99 g (C) 9.7 g (D) 4.3 g (E) 1.6 g

11. The tightly wound toroid shown consists of 100 turns of wire, each carrying a current $I = 3$ A. If $a = 12$ cm and $b = 15$ cm, the magnetic field at $r = 10$ cm, due to the current in this toroid, is ($\mu_0 = 4\pi \times 10^{-7}$ N/A²)



- (A) 400 μT (B) 500 μT (C) 600 μT (D) zero (E) impossible to calculate without additional information.

12. A long straight wire of radius R carries a current density $J = kr$ A/m² where k is a constant. The magnetic field for $r > R$ is (Hint: Current enclosed $I_c = \int J dA$.)

- (A) $\mu_0 k R^3 / 3r$ (B) $2\pi\mu_0 k R^3 / 3r$ (C) $2\pi\mu_0 k R^2 / r$ (D) $2\pi\mu_0 k R / 2$ (E) none of the above

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13. A square coil of wire with side 8.0 cm and 50 turns sits in a uniform magnetic field that is perpendicular to the plane of the coil. The coil is pulled quickly out of the magnetic field in 0.2 s. If the resistance of the coil is 15 ohm and a current of 12 mA is induced in the coil, calculate the value of the magnetic field.
- Ⓐ 5.6 T Ⓑ 0.11 T Ⓒ 7.5×10^{-3} T Ⓓ 1.4 T Ⓔ 9.1 T
14. Two small spheres attract one another electrostatically. This can occur for a variety of reasons. Which of the following statements must be true?
- Ⓐ at least one sphere is charged Ⓑ neither is charged Ⓒ both are charged Ⓓ both have the same charge Ⓔ None of these is correct.
15. Two charges Q_1 and Q_2 are distance d apart. If the electric field is zero at distance $3d/2$ from Q_1 and $d/2$ from Q_2 , along the line joining Q_1 and Q_2 , then what is the relation between Q_1 and Q_2 ?
- Ⓐ $Q_1 = 9Q_2$ Ⓑ $Q_1 = -Q_2/9$ Ⓒ $Q_1 = Q_2/3$ Ⓓ $Q_1 = -3Q_2$ Ⓔ $Q_1 = -9Q_2$
16. ψ is the wave function of a body. Which of the following properties is not the obliged requirement for ψ ?
- Ⓐ ψ must be real. Ⓑ ψ must be single-valued. Ⓒ ψ must be continuous.
Ⓓ The first derivative of ψ must be single-valued. Ⓔ The first derivative of ψ must be continuous.
17. V_p and V_g are the phase velocity and group velocity, respectively, of the de Broglie wave for an electron moving with the velocity V , and C is the velocity of light in free space. Which of the following is incorrect?
- Ⓐ $V_p > V_g$ Ⓑ $V_p > C$ Ⓒ $V_g < C$ Ⓓ $V_g = V$ Ⓔ $V_p = V$
18. How many quantum numbers are needed to describe each possible state of the electron in the hydrogen atom?
- Ⓐ 1 Ⓑ 2 Ⓒ 3 Ⓓ 4 Ⓔ 0
19. If we say the electron of the hydrogen atom is in the $3d$ state, what is its orbital quantum number l ?
- Ⓐ 0 Ⓑ 1 Ⓒ 2 Ⓓ 3 Ⓔ 4
20. The ground state of Er^{3+} ion is $^4f_{15/2}$. What is the total spin quantum number S for this state?
- Ⓐ $1/2$ Ⓑ $3/2$ Ⓒ $5/2$ Ⓓ 1 Ⓔ 2
21. Nine identical wires, each of diameter d and length L , are connected in parallel. The combination has the same resistance as a single similar wire of length L but whose diameter is:
- Ⓐ $3d$ Ⓑ $9d$ Ⓒ $d/3$ Ⓓ $d/9$ Ⓔ $d/81$

(背面仍有題目，請繼續作答)

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22. Each plate of a capacitor stores a charge of magnitude 1mC when a 100 V potential difference is applied.

The capacitance is:

- Ⓐ $5\ \mu\text{F}$ Ⓑ $10\ \mu\text{F}$ Ⓒ $50\ \mu\text{F}$ Ⓓ $100\ \mu\text{F}$ Ⓔ none of these

23. The capacitance of a parallel-plate capacitor is:

- Ⓐ proportional to the plate area Ⓑ proportional to the charge stored Ⓒ independent of any material inserted between the plates Ⓓ proportional to the potential difference of the plates Ⓔ proportional to the plate separation

24. The capacitance of a single isolated spherical conductor with radius R is proportional to:

- Ⓐ R Ⓑ R^2 Ⓒ $1/R$ Ⓓ $1/R^2$ Ⓔ none of these

25. A battery is used to charge a parallel combination of two identical capacitors. If the potential difference across the battery terminals is V and total charge Q flows through the battery during the charging process then the charge on the positive plate of each capacitor and the potential difference across each capacitor are:

- Ⓐ $Q/2$ and $V/2$ Ⓑ Q and V Ⓒ $Q/2$ and V Ⓓ Q and $V/2$ Ⓔ Q and $2V$, respectively

26. Continued from the previous question, it was reported that Felix needed to wear a pressurized suit for this jump, which of the following is NOT the possible symptom if Felix did not wear it?

- Ⓐ nitrogen forms in tissue Ⓑ hard to breathe Ⓒ bone compression Ⓓ oxygen deficiency Ⓔ blindness.

27. In a traffic accident, two cars bump into each other and come to a complete stop. The kinetic energy turns into

- Ⓐ materials deformation Ⓑ sound of collision Ⓒ heat Ⓓ all of the above Ⓔ none of the above.

28. An atomic force microscope (AFM) probe is essentially a cantilever with a nanosized tip at the free end.

One scan mode of AFM is to drive the probe as its resonant frequency while scanning on the specimen surface. Which of the following is NOT the purpose of AFM scanning at the probe's resonant frequency?

- Ⓐ To reduce the effect of surface water layer Ⓑ To reduce wear on AFM tip Ⓒ To achieve atomic resolution Ⓓ To increase scan speed Ⓔ All of the above.

29. Continued from the previous question, which of the following AFM probe has the highest resonant frequency? (assume same cantilever cross-section $A = \text{width} \times \text{height} = 120\ \mu\text{m}^2$, and same density for both materials)

- Ⓐ $300\ \mu\text{m}$ long silicon cantilever Ⓑ $150\ \mu\text{m}$ long silicon cantilever Ⓒ $300\ \mu\text{m}$ long silicon nitride cantilever Ⓓ $150\ \mu\text{m}$ long silicon nitride cantilever Ⓔ $350\ \mu\text{m}$ long silicon cantilever

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30. When an AFM probe driven at its resonant frequency is approaching a sample surface, what will happen to its resonant frequency?

- Ⓐ Increase Ⓑ Decrease Ⓒ Increase, then decrease Ⓓ Decrease, then increase Ⓔ Stay the same.

31. Two blocks of mass 300g and 200g are moving toward each other along a horizontal frictionless surface with velocities of 50cm/s and 100cm/s, respectively. If the blocks collide and stick together, find their final velocity.

- Ⓐ 20cm/s Ⓑ 10cm/s Ⓒ 15cm/s Ⓓ 25cm/s Ⓔ 5cm/s.

32. Two blocks of mass 300g and 200g are moving toward each other along a horizontal frictionless surface with velocities of 50cm/s and 100cm/s, respectively. If the blocks collide and stick together, find the loss of kinetic energy during the collision.

- Ⓐ 0.5J Ⓑ 0.225J Ⓒ 0.1125J Ⓓ 0.25J Ⓔ 0.135J.

33. The mass of an electron is $9.11 \times 10^{-31} \text{ kg}$. Comparing the classical definition of momentum with its relativistic generalization, by how much is the classical expression in error if $v=0.01c$.

- Ⓐ 0.5% Ⓑ 0.05% Ⓒ 0.005% Ⓓ 0.1% Ⓔ 0.01%

34. The mass of an electron is $9.11 \times 10^{-31} \text{ kg}$. Comparing the classical definition of momentum with its relativistic generalization, by how much is the classical expression in error if $v=0.9c$.

- Ⓐ 13.4% Ⓑ 56.3% Ⓒ 1.34% Ⓓ 5.63% Ⓔ 50%.

35. Find the average recoil force on a machine gun firing 120 shots per minute. The mass of each bullet is 10g, and the muzzle velocity is 800m/s.

- Ⓐ 1N Ⓑ 2N Ⓒ 4N Ⓓ 8N Ⓔ 16N.

36. A conducting sphere has a net charge of $-4.8 \times 10^{-17} \text{ C}$. What is the approximate number of excess electrons on the sphere?

- Ⓐ 10 Ⓑ 200 Ⓒ 3000 Ⓓ 400 Ⓔ 5×10^6

37. A charge Q exerts a 12 N force on another charge q. If the distance between the charges is doubled, what is the magnitude of the force exerted on Q by q?

- Ⓐ 3 N Ⓑ 6 N Ⓒ 24 N Ⓓ 36 N Ⓔ 48 N

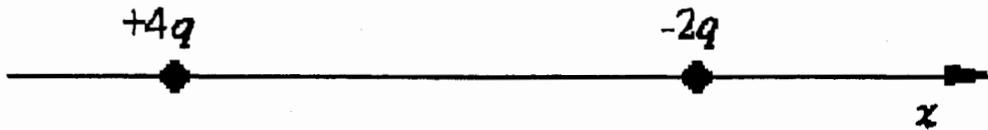
38. At what separation will two charges, each of magnitude $6.0 \mu\text{C}$, exert a force of 1.4N on each other?

- Ⓐ $5.1 \times 10^{-6} \text{ m}$ Ⓑ $2.3 \times 10^{-3} \text{ m}$ Ⓒ 0.48 m Ⓓ 2.0 m Ⓔ 40 m

(背面仍有題目，請繼續作答)

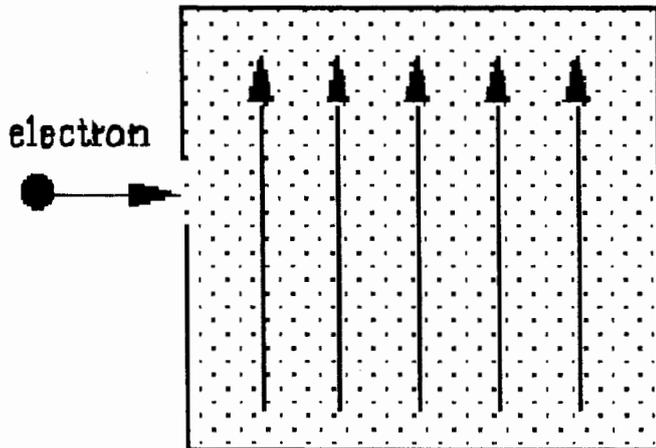
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39. At which point (or points) is the electric field zero N/C for the two point charges shown on the x axis?



- Ⓐ The electric field is never zero in the vicinity of these charges.
- Ⓑ The electric field is zero somewhere on the x axis to the left of the +4q charge.
- Ⓒ The electric field is zero somewhere on the x axis to the right of the -2q charge.
- Ⓓ The electric field is zero somewhere on the x axis between the two charges, but this point is nearer to the -2q charge.
- Ⓔ The electric field is zero at two points along the x axis; one such point is to the right of the -2q charge and the other is to the left of the +4q charge.

40. An electron traveling horizontally enters a region where a uniform electric field is directed upward. What is the direction of the force exerted on the electron once it has entered the field?



- Ⓐ to the left
- Ⓑ to the right
- Ⓒ upward
- Ⓓ downward
- Ⓔ out of the page, toward the reader

41. Which of the following effects are related to the LASER:

- Ⓐ tunneling effect,
- Ⓑ selection rule,
- Ⓒ tunneling effect + stimulated emission,
- Ⓓ stimulated emission + population inversion,
- Ⓔ Photoelectric effect

42. When heating a piece of ceramic at 1000 °C, the color changes from white to red. This phenomenon is due to which of the following effect.

- Ⓐ Black body radiation effect,
- Ⓑ Photoelectric effect,
- Ⓒ Photodiode effect,
- Ⓓ Phosphorescence effect
- Ⓔ Compton effect

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43. Electromagnetic waves with different mechanisms will result in different energy, which of the following mechanism will most likely to produce or absorb EM waves with the energy of 10^{-3} eV
- Ⓐ Rotational Energy Levels Ⓑ Vibration Energy Levels Ⓒ Compton effect Ⓓ Atomic spectra
Ⓔ Pair Production
44. Which of the following statements is the Weidemann-Franz law
- Ⓐ The electron-phonon interaction of superconductivity
Ⓑ The energy band structure of a solid determines whether it is a conductor, an insulator, or a semiconductor.
Ⓒ The ratio of thermal conductivity to electrical conductivity is the same for all metals and is a function of temperature.
Ⓓ The ferromagnetism of elements with 3d and 4f sub-shell.
Ⓔ The energy of the characteristic x-rays that are emitted by atoms.
45. Which of the following behavior can be used to differentiate a metal and a semiconductor material?
- Ⓐ X-ray diffraction to determine the lattice constant
Ⓑ Measure the reflection of visible light
Ⓒ Measure the black body radiation spectrum
Ⓓ Measure the nuclear magnetic resonance spectrum
Ⓔ Measure the electrical conductivity as a function of temperature
46. A very long string has a linear density of 5.0 g/m and is stretched with a tension of 8.0 N. 100 Hz waves with amplitudes of 2.0 mm are generated at the ends of the string. What is the node spacing along the resulting wave?
- Ⓐ 10 cm Ⓑ 15 cm Ⓒ 20 cm Ⓓ 25 cm Ⓔ 30 cm
47. A 2.50-m-long string vibrates as a 100 Hz standing wave with nodes 1.00 m and 1.50 m from one end of the string and at no points in between these two. Which harmonic is this?
- Ⓐ Sixth harmonic Ⓑ Fifth harmonic Ⓒ Fourth harmonic Ⓓ Third harmonic Ⓔ Second harmonic
48. Two loudspeakers emit 343 Hz sound waves with an amplitude of 0.10 mm. Speaker 2 is 1.00 m behind speaker 1, and the phase difference between the speakers is 90° . What is the amplitude of the sound wave at a point 2.00 m in front of speaker 1?
- Ⓐ 0.00 mm Ⓑ 0.10 mm Ⓒ 0.12 mm Ⓓ 0.16 mm Ⓔ 0.20 mm
49. A double-slit interference pattern is observed on a screen 1.0 m behind two slits spaced 0.3 mm apart. Ten bright fringes span a distance of 1.65 cm. What is the wavelength of the light?
- Ⓐ 950 nm Ⓑ 850 nm Ⓒ 750 nm Ⓓ 650 nm Ⓔ 550 nm

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50. A Michelson interferometer uses a laser with wavelength of 500 nm in vacuum. As a 5.00-cm-thick cell is slowly filled with a gas, 40 bright-dark-bright fringes shifts are seen and counted. What is the index of refraction of the gas at this wavelength?

- Ⓐ 1.0005 Ⓑ 1.0004 Ⓒ 1.0003 Ⓓ 1.0002 Ⓔ 1.0001